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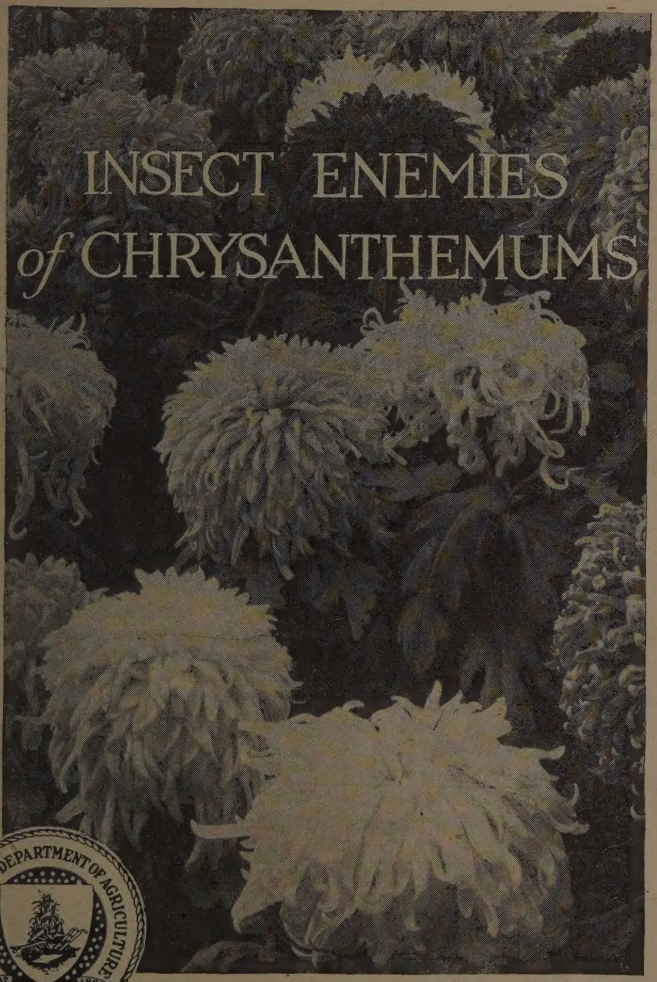
INSECT ENEMIES of CHRYSANTHEMUMS



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CHRYSANTHEMUMS, among the most beautiful and valuable of florists' productions, are subject to injury by a variety of insect pests. The chrysanthemum midge and the greenhouse leaf-tyer attack the foliage; aphids and the common red spider suck the plant juices; cutworms sever the plant stems near the soil and also attack the flower buds, ruining the blossoms.

This bulletin gives information relating to the life histories and habits of the more important pests attacking chrysanthemums and suggests practical control measures. Insecticides used are stomach poisons or contact poisons, according to the habits of the insect to be combated. In some cases fumigation with tobacco or hydrocyanic-acid gas is highly effective.

Methods of control are discussed in connection with each pest, and general formulas for insecticides and fumigants are given on pages 23 to 34.

Title page illustrates a portion of the Department's 1921 chrysanthemum show
Photograph by Ernest L. Crandall, Bureau of Plant Industry.

Washington, D. C. February 23, 1923

INSECT ENEMIES OF CHRYSANTHEMUMS.

CHARLES A. WEIGEL,

Entomologist, Greenhouse Insect Investigations, Bureau of Entomology.

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DESTRUCTIVE CHRYSANTHEMUM INSECTS.

CHRYSANTHEMUMS, which rank among the more valuable productions of the florist, are grown under ideal atmospheric conditions which not only favor the plants but enable insect pests to thrive and to multiply rapidly the year round. The losses occasioned to the chrysanthemum grower by insects alone amount to large sums annually, which, however, could be greatly reduced by proper care, based on knowledge of the insects and their habits.

Of the many insects known to attack and feed on chrysanthemums, the chrysanthemum midge, the greenhouse leaf-tyer, the black and green aphids or plant-lice, the common greenhouse red spider, thrips, and white flies are probably the most destructive. The chrysanthemum midge, which was introduced in 1915, has become widely distributed over the entire country and is now probably the most serious insect enemy of this crop. The greenhouse leaf-tyer has been reported on several occasions as practically ruining the entire stock of plants in which it occurred. Aphids frequently inflict a greater amount of injury than is credited to them. Likewise the injury caused by the common red spider, thrips, and white flies is often underestimated. Next in importance may be mentioned cutworms, scale insects, the chrysanthemum leaf-miner, and several leaf-eating insects, such as the caterpillars and leaf-beetles.

CHRYSANTHEMUM MIDGE.

The chryanthemum midge,[1] an insect of European origin, was first reported as occurring in this country in 1915. Since then it has become firmly established and is now one of the most important chrysanthemum pests, causing thousands of dollars' worth of damage annually.

[1] *Diarthronomyia hypogaea* Löw.

INJURY.

The midge renders the foliage practically valueless for commercial purposes even when only lightly infested. In severe infestations the plants fail to bloom because of the dwarfed, knotted, and gnarled condition, which prevents the formation of the new central stem (Fig. 1). When plants are attacked at the time the crown buds are setting, the flowers become distorted and are not borne upright as normal flowers should be.

FIG. 1.—Injury to terminal growth of chrysanthemum by the chrysanthemum midge.

LIFE HISTORY.

The presence of this insect on chrysanthemums is usually shown by the existence of well-developed galls. These galls, when fully developed, are about one-twelfth of an inch long and occur on the leaf, stem, or flower head of the plant, projecting obliquely from the surface. After the larvæ hatch from the orange-colored eggs, which are deposited by the female fly on the surface of tender tips and new growth, they bore their way into the tissues. As a result of this irritation cone-shaped galls are formed. When the leaf is affected (Fig. 2) the galls occur usually on the upper surface, although a slight swelling may also be observed on the opposite or under side of the leaf. Growth and development of both larva and pupa take place within the gall. When the pupa is fully developed it pushes itself out of the gall, still inclosed in the pupal skin protruding from the opening of the empty gall. In the back to allow the fly to emerge. On emerging, the fly leaves its pupal skin protruding from the opening of the empty gall. In the adult stage (Fig. 3) the midge is a fragile two-winged fly one-fourteenth of an inch long; the abdomen of the male is yellowish orange, while that of the female is reddish orange.

The flies emerge after midnight, and the eggs, which are laid early in the morning, hatch within from 3 to 16 days, depending upon the temperature. The larva or maggot, upon hatching from the egg,

moves about on the surface for a period of from 1 to 3 days prior to boring into the tissue. Within 7 days, on the average, the young galls may be readily detected. It takes from 21 to 46 days, with an average of 28 days, from the time the larva first enters the tissue until the emergence of the adult. The whole life cycle from egg to adult requires about 35 days, and under greenhouse conditions there may be six generations a year.

FIG. 2.—Galls of midge on chrysanthemum leaf.

FOOD PLANTS.

The depredations of the chrysanthemum midge in North America are confined to chrysanthemums. Practically all of the commercial sorts, both the single and pompon varieties, are attacked. While essentially a greenhouse pest this midge also lives on outdoor chrysanthemums.

CONTROL.

If the plants show only a light infestation, hand pick the gall-infested leaves daily. In heavy infestations pull up and burn the most severely infested plants, then fumigate nightly with nicotine papers or hydrocyanic-acid gas for a period of 30 to 40 days in order to kill all of the adults that emerge during such a period and thus prevent further egg laying for future generations. Fumigation should not begin until after 12.30 a. m., because the adults do not emerge before that time. Hydrocyanic-acid gas is not recommended unless in the hands of a competent fumigator.

If fumigation is not practicable, persistent spraying is recommended for a period of 4 to 6 weeks, the 40 per cent nicotine sulphate solution being used as outlined on page 26, which should be applied every second or third day, preferably late in the afternoon. This operates against the eggs and also against the adults at the time of their emergence.

PREVENTION.

Growers should carefully examine all chrysanthemums received, as well as all material intended for shipment or distribution, to see that they are free from this pest.

A satisfactory method of obtaining cuttings free from the midge when the previous season's stock has been infested is to plant the stock in benches or coldframes directly after the season's crop has been removed. Follow this by thorough treatment with a mixture consisting of equal parts of dry air-slaked lime and tobacco dust. It is advisable to keep all new growth covered with this mixture until further operations in the spring. Additional information on this pest may be had by consulting Department Bulletin 833, United States Department of Agriculture.

FIG. 3.—Chrysanthemum midge: Adult female.

GREENHOUSE LEAF-TYER.[2]

The greenhouse or celery leaf-tyer during recent years has been responsible for much injury to chrysanthemum, cineraria, and snapdragon and in some instances has destroyed the plants attacked (Fig. 4).

INJURY.

The injury is caused by the larvæ, or caterpillars (Fig. 5), feeding on the under side of the foliage, where they eat away the soft tissue, usually leaving the top surface intact. At times, however, they devour the entire tissue in the areas where they are feeding. Normally they feed within lightly woven silken webs, between the surfaces of the edge of a single leaf folded over, or between two or more contiguous leaves tied together. The injury resulting from these habits is twofold: The plant is weakened, and the disfigurement of the leaves greatly diminishes the market value.

LIFE HISTORY.

The eggs (Fig. 6, *c*) are about three-fifths of a millimeter wide, flattened, with raised centers, rounded in outline, and pearly white. In bright sunlight they appear iridescent. They are laid mostly on the under side of the leaves, either singly or in masses, and in the latter case they overlap. They hatch in from 5 to 12 days or longer.

The larvæ or caterpillars (Figs. 5 and 6, *d*, *e*, *f*), on emerging from the egg, are of a creamy white translucent color, the body being covered with long whitish hairs. Soon after feeding they take on a light greenish appearance. When resting on the under side of the leaf the head and fore part of the body are curled to the side. If disturbed they drop and suspend themselves on silken threads. They

[2] *Phlyctaenia rubigalis* Guen.

shed their skins four times before reaching the full-grown stage, which is then three-fourths of an inch long. When full grown they are dark green on the back and marked with longitudinal stripes. The sides and under surface are of a paler color. Because of the overlapping of generations, larvæ or caterpillars in all stages of development may be found on plants in greenhouses at almost any time.

When ready to pupate the caterpillar folds over a portion of the leaf upon which it is feeding and fastens it with strands of loosely woven silk. In other cases the larva may form a slight cocoon and transform to a pupa within a shelter constructed in the same manner by drawing down a contiguous leaf as a covering, and fastening the two leaves together. At first the pupa (Fig. 6, *g*, *h*) is of a shining light brown color, later changing to darker chocolate color, and sparsely haired. From this stage, which lasts from 10 to 12 days, or longer, depending on the temperature, the adult or parent moth finally emerges.

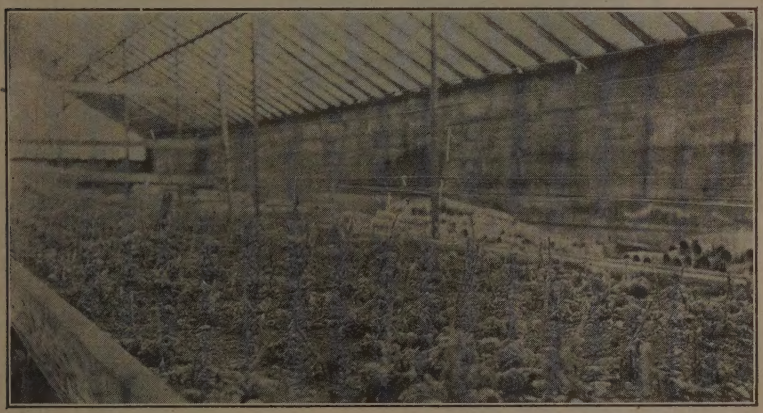

FIG. 4.—Entire house of chrysanthemums destroyed by larvæ of the leaf-tyer.

The moth (Fig. 6, *a*) has a wing expanse of three-fourths of an inch, and is of a pale brownish or rusty brown color marked crosswise with darker lines. When at rest it assumes a characteristic triangular shape (Fig. 6, *b*), measuring three-eighths of an inch at the widest part. The moths are very quiet during the day and are found resting on the under sides of leaves, under the benches, or in other sheltered places in the greenhouse. After dusk they become active and fly about or fly from plants upon the least disturbance. Egg laying may begin on the day they emerge, and the adults live from 5 to 15 days, or an average of 10 days.

At Washington, D. C., it takes from 36 to 43 days for development from egg to adult and there may be eight or more generations a year under greenhouse conditions.

CONTROL.

Inasmuch as the cuttings are taken early in the spring for the ensuing season's crop, and since the larvæ are more easily detected

when the plants are small, it is evident that a serious infestation can be easily abated by keeping a vigilant watch for the caterpillars at this time. Hand-picking is then very effective and practical, provided not too many plants are concerned.

FIG. 5.—Larva of leaf-tyer on chrysanthemum foliage. (Greatly enlarged.)

Young plants may be dipped in a solution of arsenate of lead prepared according to directions on page 24. A thorough coating of the under surface of the foliage where the young caterpillars are feeding is thus insured.

Dusting with a mixture of 9 parts of superfine sulphur and 1 part of calcium arsenate or arsenate of lead by means of a hand blower gun is effective against the larger larvæ. Owing to the fineness of this material it will sift into the fine webbing, reaching the caterpillars more easily than the liquid sprays. Paris green used at the rate of 1 teaspoonful to every 3 gallons of water is also recommended.

In recent experiments it has been demonstrated that the adults can be controlled, without injury to the plants, by fumigation with hydrocyanic-acid gas, using 1 ounce per 1,000 cubic feet for 1 hour.

The Ohio Experiment Station recommends carrying a lighted gasoline torch in one hand slowly through the greenhouse paths, and with the other gently striking a fly swatter or stick against the leaves so as to start the moths into flight. The moths fly into the flame of the torch, burn off their wings, and fall to the ground. An assistant should follow to trample them to death as soon as they fall. As many as 12 to 15 moths have been seen flitting around the flame at one time. Another method of combat recommended is to strike the adults when they swarm against the glass at dusk.

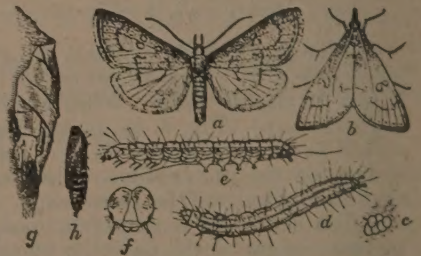

FIG. 6.—The greenhouse or celery leaf-tyer: *a*, Moth; *b*, same in natural position at rest; *c*, egg mass; *d*, larva from above; *e*, same from side; *f*, head of same; *g*, pupa case; *h*, chrysalis. *a*, *b*, *d*, *e*, *g*, *h*, One-half larger than natural size; *c*, twice natural size; *f*, more enlarged. (Chittenden.)

GREENHOUSE WHITE FLY.

As a common and annoying pest to the florist and gardener the greenhouse white fly[3] may easily be placed in the front rank. The white fly attacks especially plants like calendula, primula, ageratum, and coleus, although it feeds on a long list of other flowering and ornamental plants grown under glass. Chrysanthemums are no exception. Instances are known where crops like calendula and ageratum can hardly be grown without remedial measures.

INJURY.

The continual sucking of the plant juices by this insect results in a gradual yellowing of the lower leaves, followed by the higher leaves, which finally dry up and drop to the ground, greatly impairing the health and vitality of the plant. A secondary injury is the excretion of a honeydew or sweetish liquid by the larvæ and pupæ. These droplets fall to the upper surface of the foliage directly below, giving it a glazed appearance and serving as an excellent medium for a sooty fungus which eventually destroys the leaves.

LIFE HISTORY.

Although of tropical and subtropical origin, the white fly is now generally distributed throughout the United States, as well as in Europe. Like aphids, red-spider mites, and scale insects, it obtains its food by sucking the plant juices. The mature white flies are four-winged and hardly more than one-sixteenth of an inch long. Soon after the adult emerges from the pupal case, the entire body becomes covered with a white substance, giving it a characteristic floury appearance, hence the popular name, white fly (Fig. 7). The adult white fly, as well as the scale-like larva, is provided with sucking mouth parts. It lives for a month or longer in this stage, feeding almost continuously. The adult female lays the eggs in a circle while feeding, the beak serving as a pivot, and lays as many as 10 to 20 in each circle.

Feeding is confined usually to the upper and tenderest growth, and invariably to the under surface of the leaf. Here, too, naturally, the eggs are deposited, although they may be found upon the tender leaf petioles or scattered on the upper surfaces of the leaves. They are egg-shaped and are suspended from the leaf by a short slender stalk. On account of their minute size they are hardly discernible to the naked eye. From the eggs, which hatch in from 10 to 12 days under natural greenhouse conditions, flat oval larvæ appear. Even though provided with legs, they crawl only a very short distance from the eggshell, then settle down, and commence to feed by inserting the threadlike beak into the plant tissue. They feed for 5 or 6 days, after which they molt for the first time. The next two stages are much like the first except for size. Each requires from 4 to 6 days. The legs and antennæ now become functionless. When the

[3] *Trialeurodes vaporariorum* Westw.

larvæ attain their full growth they become inclosed in the last or fourth larval skin, in which pupation takes place. In outline the pupæ are similar to the larvæ except that they are thicker, have a boxlike appearance, and are provided with long slender wax rods.

FIG. 7.—Leaf heavily infested with white flies, showing all stages. Insert: Adult male and female white flies.

On emerging from this case a T-like opening appears down the back through which the adult escapes, leaving the glistening white pupa case attached to the leaf. These pupa cases, as well as the living pupæ, are quite conspicuous when present in abundance. Shortly after emergence of the fly, its wings unfold and the development of

the insect is complete. The whole cycle, from egg to full-grown adult, requires approximately 5 weeks, viz, egg stage 10 to 12 days, larva 13 to 18 days, and pupa stage 12 to 16 days.

CONTROL.

In the control of this pest advantage is taken of the fact that it requires from 12 to 16 days to complete the pupa stage from which the adult fly emerges. Three or four fumigations with hydrocyanic-acid gas, approximately 10 days to 2 weeks apart, hold this insect in control. The exposure should last only one hour and the dosage employed need not exceed one-half ounce of sodium cyanid per 1,000 cubic feet of space. In this manner the several generations of adults are killed as they emerge, preventing egg deposition for future generations. This is a very reliable and effective means of subduing the white fly.

If fumigation with this gas is inadvisable or the proper facilities are not available, thorough spraying with fish-oil soap solution or the 40 per cent nicotine solution may be employed (see p. 26), preferably preceded by one or two tobacco fumigations.

COMMON GREENHOUSE RED SPIDER.[4]

The common red spider which is distributed throughout the United States is cosmopolitan in its feeding habits. Chrysanthemums, next to roses, violets, sweet peas, and carnations, are frequently severely damaged by this pest. Because of its extremely small size it is more properly designated by the term "spider mite." The full-grown individual (Fig. 8) is about one-fiftieth of an inch long and about half as wide. It is of a reddish color, in general, very frequently tinged with yellow, green, or orange. The body has two dark spots, one on each side, due to the food contents.

FIG. 8.—The female red spider. Highly magnified. (McGregor and McDonough.)

INJURY.

The red-spider mite injures chrysanthemums by puncturing the foliage with the beak, afterward extracting the liquid contents of the plant cells, surrounding the point of attack. In this manner the green coloring matter is withdrawn, leaving small dead areas and causing the leaves to lose their normal color and later to assume a yellowish lifeless color.

On chrysanthemums the injury is usually confined to the tip growth of the plant, where the most tender foliage is found, causing the development of irregular heads. Flowers that have been attacked are unsalable, as the petals shrivel and become discolored. When the insects are numerous they cover the heads of the plants with their webs (Fig. 9). The amount of damage in greenhouses by the red-spider mites is dependent in a large measure upon the

[4] *Tetranychus telarius* L.

amount of moisture present as well as the nature of the soil. In high temperatures or dry atmospheres they flourish well and they increase in numbers wherever plants are growing in sandy soils.

LIFE HISTORY.

The eggs are deposited on the under surface of the leaf or more often in the webbing which the mites spin. They are very minute, transparent, and resemble dewdrops. Within four or five days after they are laid, minute six-legged larvæ hatch from them, begin feeding almost immediately, and continue to do so for a little over a day. They then fasten themselves firmly to the leaf and enter a resting or premolting stage, which lasts for about a day. After this the skin is shed and an eight-legged creature appears which is called the primary nymph. After feeding for one day the primary nymph enters a secondary quiescent or premolting period, which lasts approximately the same length of time as the larval quiescent stage. A secondary nymph then emerges and is by far the most voracious feeder of the immature forms of these mites. This stage passes through similar feeding and resting periods, each requiring about one day. The full-grown adult female then emerges, establishes herself on the leaf, and feeds for two or three days before she commences egg laying. At this time mating and migration take place. For the next 8 or 10 days eggs are deposited at the rate of 6 per day, making a total of 50 to 60 eggs laid by a single female. In high temperatures the females may live for about 14 days, but in lower temperatures this period is longer. Seven or eight days are required to complete development from egg to adult, making the total life cycle, including the length of the life of the adult, about three or four weeks.

FIG. 9.—Chrysanthemum bud badly infested with red spiders. Note the presence of the web surrounding the leaves and the stem of the plant. (Ewing.)

CONTROL.

Owing to the peculiar structure of the respiratory system of mites, they are very resistant to fumigation with tobacco or hydrocyanic-acid gas, and neither of these fumigants is a practicable means of control.

Frequent syringing with clear water under pressure of at least 25 to 30 pounds is very effective in keeping this pest in check. This operation dislodges the mites, causing them to fall to the ground, where they become lost in the mud. It also disturbs the webbing used by these creatures for egg deposition and protection. Syringing should not be employed on plants that are subject to mildew and can not stand much moisture. Nozzles specially adapted for the purpose should be used to avoid drenching the beds too much, and syringing should be so done as to have the surplus water run off onto the walks. Watering the walks frequently, which keeps the atmosphere from becoming too dry, retards the development of the mites.

Spraying with a warm soap solution prepared by dissolving 1 pound of laundry or fish-oil soap in 4 gallons of water is effective except against the eggs, and should be applied at weekly intervals.

Frequent dusting with superfine sulphur is also very effective in holding the mites in check. This material is best applied by means of modern hand blower guns, several types of which can be purchased.

APHIDS.

Chrysanthemums often suffer severe injury from the attacks of small greenish, brownish, or black aphids or plant-lice. Popularly these insects are occasionally referred to as "lice," "aphids," "black fly," "green fly," etc. The principal injury to these plants is occasioned by the "black aphis"[5] (Fig. 10) and "green aphis,"[6] both of which apparently confine their attack to chrysanthemums.

INJURY.

Aphids are provided with sucking mouth parts with which the plant tissues are pierced and the vital juices sucked up. As a result of the continuous draining of the plant juices, the tender growth becomes stunted and the leaves curl up, causing serious disfigurement and eventually death of the plants. Owing to their small size and concealed position, aphids are frequently overlooked until they have increased to considerable numbers. These insects have a characteristic habit of excreting a sweetish liquid or honeydew which attracts ants, wasps, bees, and flies, and serves as a medium for the development of sooty mold, an objectionable black deposit which reduces or destroys the commercial value of the plants.

LIFE HISTORY.

Aphids differ little in their life history, and a general discussion will suffice for the whole group. They are gregarious in their habits, living in colonies, and are invariably found on the under sides of the leaves and young terminal growth. In these colonies may be found

[5] *Macrosiphoniella sanborni* Gill. [6] *Rhopalosiphum rufomaculata* Wils.

wingless and winged females in all stages of development, from the small newly born to the full-grown individual (Fig. 10). These adults give birth to living young, without fertilization by the male. Under constant-temperature conditions this method of reproduction may continue throughout the entire year. Outdoors and under natural conditions many of the species develop females which lay eggs. The newly born aphids reach maturity in a very short time and in turn give birth to more young. They are prolific and develop very rapidly. A single female may give birth to as many as 100 young at the rate of from 4 to 9 individuals a day. Thus they increase to destructive numbers in a very short period.

FIG. 10.—Portion of chrysanthemum stem heavily infested with aphids.

NATURAL ENEMIES.

Aphids are kept in check to a certain degree by predacious and parasitic enemies. This, however, should not be construed to mean that no control measures are necessary, because if dependence were placed on natural enemies alone the outcome could not be predicted. The best examples of predacious enemies are ladybird beetles, in both the adult and larva stages. Of the parasites, small wasp-like insects, which live within the body of their host, are the most important. A parasitized aphid is easily detected by the fact that the outer or body wall becomes hard and later turns brown or brownish black. When the parasite is full grown it cuts a circular hole through the posterior part of the body of the aphid, through which it emerges. As a rule these natural enemies are most active during warm, dry weather.

CONTROL.

The standard methods of controlling aphids in greenhouses are fumigation with hydrocyanic-acid gas (p. 32), vaporization of nicotine extracts (p. 31), and spraying with contact insecticides (p. 25).

The fumigation with hydrocyanic-acid gas is very practicable, especially during hot weather, when it is inconvenient to smoke with tobacco extracts, which require the house to be closed for a greater portion of the night. With hydrocyanic-acid gas the operation is over in one hour. Even though the temperatures run high, the injury likely to result therefrom would not compare with that from tobacco

smoking. The use of hydrocyanic-acid gas is not recommended, however, except in the hands of one fully qualified to handle it, owing to the deadly poisonous character of the gas.

The standard material used for spraying against aphids, either in greenhouses or on outdoor plants, is the 40 per cent nicotine sulphate solution prepared according to the directions given on page 26. Whatever their position on the plants, the insects must be hit or wetted by the spray solution. This is best accomplished, in greenhouses, by using the modern bucket pump, compressed-air sprayer, or knapsack sprayer, equipped with an elbow mist or disk nozzle.

Another satisfactory remedy is to dust the plants early in the morning with dry tobacco dust or commercial preparations containing not less than 2 per cent of free nicotine.

THRIPS.

Chrysanthemums as well as many other ornamental and greenhouse plants are subject to serious injury by minute, slender, active insects properly known as thrips which first rasp the foliage and then suck the juices. Other portions of the plant, as the tender new growth, buds, and flowers, are not immune from their attack. Several species of thrips are concerned, of which two or more may be found simultaneously on the same plant.

On chrysanthemums the greenhouse thrips, the onion thrips, the flower thrips, and the sugar-beet thrips are most frequently intercepted. Thrips belong to a quite distinct order of insects whose mouth parts differ from those of other insects by being intermediate in structure between those of chewing and sucking insects. The several species just mentioned are much alike in their feeding habits and general structure, and a discussion of one form, the common greenhouse thrips,[7] will give a fair idea of the whole group.

DESCRIPTION AND LIFE HISTORY.

The adult greenhouse thrips is minute in size, being about one-twenty-fourth of an inch long. In general it is of a dark brown color, the tip of the body being much lighter. It is provided with two pairs of featherlike wings (Fig. 11). The eggs are laid in the leaf tissue by the adult female while feeding. Under greenhouse conditions the eggs hatch out minute white larvæ about 8 days after deposition. During the period of growth, which requires from 10 to 20 days, these white larvæ feed actively in colonies, causing the same type of injury as is done by the full-grown adults. At the completion of this stage the full-grown larvæ change to the prepupa and pupa or resting stages, during which time no food is taken. These stages require from 4 to 6 days, after which the fully developed adult thrips emerges. A generation is therefore completed in from 20 to 33 days, and under greenhouse temperatures many generations occur throughout the year.

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[7] *Heliothrips haemorrhoidalis* Bouché. The onion thrips is *Thrips tabaci* Lind.; the flower thrips, *Frankliniella tritici* Fitch; the sugar-beet thrips, *Heliothrips femoralis* Reuter.

INJURY.

The greenhouse thrips confines its damage almost entirely to the foliage. Both adults and larvæ obtain their food by piercing and rasping the leaf surface, and after lacerating the tissue the plant juices are sucked out, leaving a white spot at the point of attack. In the beginning these spots show more plainly on the lower surface. As attack continues the spots coalesce, forming blotches and resulting in dead areas and a final wilting and dropping off of the foliage.

FIG. 11.—Greenhouse thrips: Adult female enlarged about 50 diameters, and greatly enlarged drawing of antenna underneath. (Russell.)

While feeding, the thrips void minute drops of reddish fluid which later turns black, presenting an unsightly appearance. The injury is therefore twofold: First, the growth is checked or even killed by the constant draining of the plant juices; and, secondly, the commercial value is much reduced because the color and beauty of the foliage for ornamental uses is spoiled by their feeding and the black discoloration due to the fluid they exude.

CONTROL.

Essentially the same measures may be employed for thrips as are used against the aphids, viz, fumigation with hydrocyanic-acid gas, tobacco smudges from the liquid extract or from paper impregnated with it, spraying with contact insecticides, and dusting the foliage with superfine tobacco dust.

CUTWORMS.

The general term "cutworms" designates the larvæ or young of many forms of night-flying moths which are all more or less similar in general appearance and habits. Annually these insects cause extensive loss through their depredations to crops throughout the United States. The commonest greenhouse species, the variegated cutworm,[8] feeds primarily on chrysanthemums, carnations,

FIG. 12.—Variegated cutworm: *a*, Moth; *b*, normal form of caterpillar, side view; *c*, same in curved position; *d*, dark form, view of back; *e*, greatly enlarged egg, seen from side; *f*, egg mass on twig. (Howard.)

smilax, sweet peas, asparagus, and violets. Entrance to greenhouses probably is gained either by the moth flying in through the ventilators and depositing her eggs on the plants, or in the larva stages in the soil when the benches are being filled with sod.

INJURY.

The variegated cutworm in greenhouses, in addition to the usual cutworm habit of cutting off young plants near the surface of the soil, or severing the stems a little higher, as well as feeding on the tender leaves of plants more advanced in growth, attacks the flower buds of chrysanthemums and carnations, in particular, and eats out the centers, thus spoiling the blossoms. All stages of development may be found throughout the year under greenhouse conditions, although their ravages are likely to occur mostly in the spring months and continue throughout June and July. When present in large numbers, they may cause considerable injury before their presence

[8] *Lycophotia margaritosa* Haw.

is detected. Owing to their large size when full grown, these caterpillars often destroy more plants in a single night than they can devour.

LIFE HISTORY.

The eggs (Fig. 12, *e*, *f*) of the variegated cutworm are laid at night by the parent moth or miller, mostly on the under sides of the leaves or in rings about the stems, and are about one-fiftieth of an inch in diameter. They are globular, strongly ribbed, and creamy white when first laid but become darker just before hatching. From 200 to 500 eggs are deposited by a single female moth in masses of 60 or more. These eggs hatch out small larvæ in 5 or 6 days, and these begin feeding almost immediately on any succulent growth available. Because of their night-feeding habit they are rarely seen in the daytime. On close examination of the soil at the base of plants or under débris about the beds the various stages may be found from the small to the smooth, full-grown, robust, soft-bodied, cylindrical caterpillars, about 1½ inches long, varying in color from pale or dirty gray to nearly black and spotted with a row of four to six yellow spots down the middle of the back. (Fig. 12, *b*, *c*, *d*.) The caterpillar reaches maturity in about 25 to 30 days, after which it enters the ground and forms an earthen cell in which transformation to the reddish brown pupa takes place. This stage takes from 15 to 20 days, after which the adult moth or miller emerges. The moth (Fig. 12, *a*), which is brownish in color and marked with black mottlings, has a wing expanse of 1¾ inches. It lives for about 7 to 10 days and during this period the eggs are deposited. The whole life cycle requires from 45 to 54 days, depending on the temperature of the greenhouse.

CONTROL.

Cutworms are easily controlled by using a poisoned bait made up of bran, alfalfa meal, or middlings as a basis, the formula for which is given on page 25.

Since the cutworms feed at night or on dull cloudy days, and as the bait is more attractive when fresh, it should not be applied until evening or at dusk. Scatter the mash sparingly about the bases of the plants, repeating several times at intervals of 3 or 4 days if they reappear.

Spraying or dipping the plants in a solution of lead arsenate such as is used for other chewing insects is quite effective, especially for small plants. (See p. 24.) When only a few are present, hand picking may be practiced.

PREVENTION.

Soil brought into the greenhouse should first be sterilized by steam or cleared of cutworms by the poisoned bait.

SCALE INSECTS.

Several forms of scale insects occasionally become serious pests on chrysanthemums. The greenhouse Orthezia,[9] the hemispherical

[9] *Orthezia insignis* Dougl.

scale,[10] and mealybugs,[11] are the most troublesome. They migrate to chrysanthemums from neighboring plants which are infested. Being provided with sucking mouth parts, they sap the vital fluids of the plants, causing a loss of color, wilting, and eventual death of the affected parts, if not controlled.

FIG. 13.—Greenhouse Orthezia on stem of plant.

THE GREENHOUSE ORTHEZIA.

The adult female of the greenhouse Orthezia (Fig. 13) is elongate, scalelike in appearance, with prominent long legs, and about one-twelfth of an inch long. The bare upper front portion of the body is olive green and covered with waxlike plates. A characteristic of the female is the white cylindrical egg sac which projects from the hind end of the body and is frequently much larger than the latter. The young hatch within this sac and then crawl out of an opening at the hind end. After this they may be found moving about actively on any part of the plant. When first born the body is devoid of the waxy plates, but it is soon completely enshrouded within them. The males, which are two-winged, are rarely seen. The adult female lives about four months. The entire cycle requires about six months, hence there may be two generations annually.

FIG. 14.—Hemispherical scales on stem of plant.

THE HEMISPHERICAL SCALE.

While primarily an obnoxious fern pest, the hemispherical scale (Fig. 14) frequently infests chrysanthemums and causes considerable injury. As the specific name indicates, this scale insect is hemispherical, very convex, smooth and shiny, with flat edges. The color varies from a light to a dark

[10] *Saissetia hemisphaerica* Targ. [11] *Pseudococcus citri* Risso; *P. adonidum* L.

brown and the insect is a little more than three-eighths of an inch long and its width is a trifle less. It reproduces by means of eggs which are deposited beneath the scale.

THE MEALYBUGS.

In general mealybugs are characterized by an oval or elongate body, which is more or less coated with a white mealy secretion. The body margins have protrusions of white waxy filaments which distinguish the two more common greenhouse species from each other. In the case of the short-tailed mealybug, none of the filaments are nearly as long as the body, while the long-tailed mealybug has four marginal filaments or tassels extending from the hind end like a long tail. These are about as long as the body. The short-tailed mealybug is the larger of the two. The eggs are laid by the female in a protective mass of waxlike webbing or secretion under the tip of the abdomen. They are usually found in clusters and multiplication is very rapid, as each female may lay from 300 to 500 eggs. Egg-laying continues for a period of about 10 days and from 20 to 30 eggs are laid daily by each individual female. The eggs hatch in 14 days and the larvæ are much like the adults except for their smaller size and being devoid of the wax secretion. All stages are present at the same time, and they may be found on the plants throughout the year. Their usual place of abode is on the under side of the leaf, along the veins and ribs, and in crevices at the base of the petiole.

FIG. 15.—Adult of the margined blister beetle (*Epicauta marginata*).

CONTROL.

Syringing with clear water under pressure in the same manner as is recommended for red-spider mites is probably one of the most effective methods of control for mealybugs. For all scale insects spray frequently, using fish-oil soap or nicotine-soap solution prepared as directed on page 26, or place poisoned honey bait (see formula on p. 20) about the greenhouse or garden to kill the ants which attend them. In general, ants are the first consideration in control of mealybugs and scale insects. Fumigate with hydrocyanic-acid gas (p. 32).

OCCASIONAL PESTS.

FIG. 16.—The tarnished plant-bug: Adult stage at left; last stage of nymph at right. Enlarged nearly four times. (Chittenden.)

In addition to the insects treated before, several species of both leaf-eating and sucking insects occasionally injure chrysanthemums. Among the most frequently intercepted of the leaf-eating group are grasshoppers, blister beetles (Fig. 15), rose beetles, the larvæ of the burdock or chrysanthemum leaf-miner [12] and of the marguerite fly,[13] and various forms of caterpillars, such as the corn earworm,[14] European corn borer,[15] cabbage looper,[16] and "yellow bear."[17] In the sucking group may be mentioned primarily the plant-bugs (Figs. 16, 17), leafhoppers, and the lace-winged leaf-bugs. By spraying with an arsenate of lead solution to which nicotine sulphate has been added, both types of insects mentioned above can be effectively held in control.

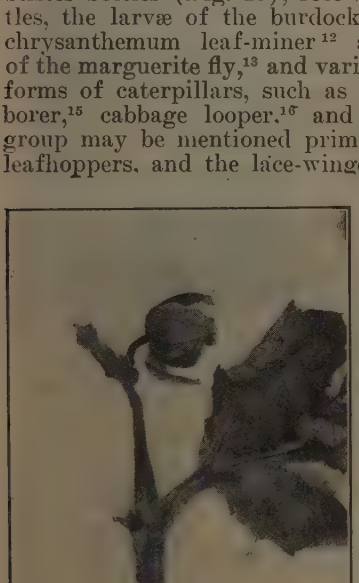

FIG. 17.—Bud and tip injury by the tarnished plant-bug to chrysanthemum.

Aside from the pests named above, ants, termites (white ants), white grubs, slugs, snails, sowbugs, and millipeds may, at times, cause injury to both indoor and garden-grown chrysanthemums.

ANTS.

Ants frequently become very troublesome by building their nests and galleries under the roots of plants or directly in the pots. Their presence in greenhouses is usually an indication that some of the plants are infested with one or more species of honeydew-producing insects, such as mealybugs, soft scales, aphids, etc. Ants protect these insects from natural enemies, transfer them from time to time to young succulent growth, and build shelters for their protection. (Fig. 18.) They collect and transfer to their nests the honeydew or sweet fluid excreted by the insects. This habit of the ants is taken advantage of in the use of poisoned bait.

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[12] *Agromomyza maculosa* Malloch.
[13] *Phytomyza chrysanthemi* Kowarz.
[14] *Heliothis obsoleta* Fab.
[15] *Pyrausta nubilalis* Hübn.
[16] *Autographa brassicae* Riley
[17] *Diacrisia virginica* Fab.

CONTROL.

Recent experiments have demonstrated that ants can be satisfactorily controlled by using the following poisoned sirup as a bait:

Take granulated sugar, 15 pounds; water, 7½ pints; and tartaric acid (crystallized), ¾ ounce. Boil these ingredients slowly for 30 minutes and allow to cool. Then dissolve three-fourths of an ounce of sodium arsenite ($NaAsO_2$) in one-half pint of hot water and allow to cool. Combine the two solutions by thorough stirring. Finally add 1½ pounds of honey. Saturate small pieces of sponges with the poisoned sirup and distribute about the infested places sheltered with inverted thumb pots placed over them. The ants convey this material to their nests and die as a result of feeding on it.

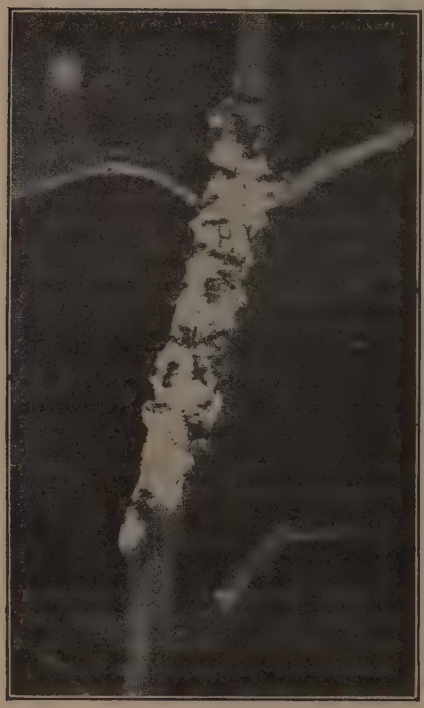

FIG. 18.—Ants attending a group of mealybugs. Their almost constant presence protects the mealybug from its natural enemies. (Woglum and Borden.)

Spray walks, soil under pots and benches, and woodwork with kerosene nicotine oleate (p. 26).

TERMITES.

Termites or white ants (Fig. 19) are occasionally reported as injuring chrysanthemums and other greenhouse plants. These insects come up through the ground or burrow up through the wooden bench legs and form dirt galleries over the supports, or run galleries the entire length of the wooden benches (Fig. 20). They injure and kill the plants very quickly by eating out the main stock of the root. Termites gain entrance to potted plants through the drainage holes, and in case of bench plants they work their way up directly through the woodwork in which they have their nests.

CONTROL.

In the case of potted plants or benches which can not be immediately replaced, soak the ashes or sand under the pots of the infested benches with a 5 per cent solution of kerosene emulsion, or with kerosene nicotine oleate (p. 26), or a solution of 1 ounce of sodium cyanid dissolved in each gallon of water. Carbon disulphid,

which is a very volatile liquid, may be used in moist soil which is more compact. This is more easily applied by punching a hole near the base of the plants, pouring in the liquid, and immediately covering it with earth, so as not to allow the gas to escape.

FIG. 19.—Mature "worker" of the white ant known as *Reticulitermes flavipes*; etherized specimen. Enlarged nearly seven times.

FIG. 20.—Work of white ants. (Snyder.)

In severely infested greenhouses, the entire infested woodwork should be removed and replaced, preferably by upright steel frames set in concrete bases. If it is necessary to use wooden uprights, they should be set in concrete or rest on stones or bricks above the surface of the ground.

WHITE GRUBS.

The larvæ of May beetles or "June bugs" (Fig. 21) are frequently introduced into greenhouses when the benches or beds are being refilled with composted sod. Outdoors they are frequent pests. They feed primarily on the roots, causing the plants to wilt and eventually die.

FIG. 21.—A white grub, or May beetle: *a*, Beetle; *b*, larva or grub; *c*, pupa. Enlarged one-fourth. (Chittenden.)

CONTROL.

Pour 1 ounce of carbon disulphid into a hole in the soil about 8 inches from the base of the plant and quickly cover up by tamping down the soil over it. As this material is very inflammable, keep it away from lights and fires. Sterilize the soil, if heavily infested, before filling benches or beds.

SLUGS AND SNAILS.

In greenhouses and gardens slugs[18] and snails are often insidious pests. They usually confine their attack to young tender seedlings, which they devour, although the large plants are not immune from their attacks. In size they are from one-half inch to 4 inches long, and their colors vary from a yellowish gray or brown mottled with black, to dark gray and black (Fig. 22). A sticky mucous secretion is exuded from their bodies, which adheres to any object that they crawl over, leaving glistening trails behind. The usual haunts are in dark and damp locations, especially under flowerpots or old decayed wood.

Fig. 22.—The spotted garden slug. (White.)

CONTROL.

Remove all decaying boards or débris and then apply air-slaked lime, finely pulverized salt, or road dust liberally. Cutting beds may be protected by placing a border of salt, soot, or dry lime around them. Boiled potatoes or sweet potatoes sprinkled with dry white arsenic or dry Paris green serve as an effective bait. Saturate the soil with mercuric chlorid solution (p. 27).

SOWBUGS OR "PILLBUGS."

Sowbugs are very active on being exposed to light, although some forms roll themselves up into the shape of a round pill on the least disturbance, and are therefore spoken of as "pillbugs." They are dark gray and have oval, flattened bodies. They are not true insects. Their usual place of abode is under some such shelter as decayed boards or flowerpots, in decaying manure, or in any dark moist place where decay is in progress. Cutting beds are preferred by them, although they feed on roots and tender portions of older plants.

CONTROL.

Sprinkle the surface of the soil lightly with a dry mixture consisting of 9 parts of sugar and 1 part of dry Paris green. A similar remedy may be substituted which is prepared as follows:

White flour	2 parts.
Sugar	2 parts.
Paris green	1 part.

Apply in the same manner as the preceding mixture.

Dry tobacco dust is very repellent to sowbugs. Kerosene nicotine oleate (p. 26) is also very effective.

[18] The spotted garden slug (*Limax maximus* L.) is treated in Farmers' Bulletin 959.

MILLIPEDS.

These hard-shelled wormlike creatures are often called "thousand-legged worms." They are distinguished from nearly related forms by having two pairs of legs on each body segment except the first three. Primarily they injure the roots, although the stems of plants are frequently attacked. Usually they are associated with manure which contains considerable decaying vegetable matter, and they are abundant in damp places, especially under flowerpots.

CONTROL.

Vegetables dipped in dry Paris green or in dry lead arsenate and placed about the benches are a very effective remedy. Drenching the soil with a solution of one-half ounce of mercuric chlorid to 3 gallons of water (p. 27) or with kerosene nicotine oleate (p. 26) also operates against them. Dry Paris green and sugar (1 to 9), as recommended for sowbugs, is also very effective.

PREPARATION OF INSECTICIDES.

The use of chemicals in some form of spray or by fumigation for the control of insect pests is now recognized as a standard practice. Practical and intelligent employment of these chemicals or insecticides depends upon an accurate knowledge of the manner in which the insects feed. The fundamental question is whether the insect is provided with chewing or sucking mouth parts. Insects of the chewing type bite off and swallow portions of the plant tissues and require that stomach poisons, such as the arsenicals, be applied to the plants. Cutworms, leaf-tyer larvæ, beetles and their grubs, crickets, grasshoppers, etc., are examples of this group. The sucking insects, on the other hand, are not affected by stomach poisons, because they are provided with a beak which they thrust down through the outer layers of the leaves into the soft, succulent tissues beneath and by means of which they extract the vital juices. Substances must therefore be used which come into contact with the insect's body and which kill by exerting a caustic action on the body tissues, by smothering the insect with poisonous fumes given off from the insecticides, or by entering the breathing pores and closing them or causing paralysis by their effect upon the insect's nervous system. Insects to be treated in this manner include aphids, thrips, and scale insects. Frequently deterrent substances are used which repel the insects.

Briefly, the chemicals used as insecticides may be placed in three classes, viz, stomach poisons, which are applied to the plants and devoured with the portions of the plants upon which the insects feed; contact sprays, which are applied to the insects, and incidentally to the plants, because one can not be hit without hitting the other; and fumigants, which fill the entire atmosphere with gaseous fumes and suffocate the insects. Hydrocyanic-acid gas and tobacco extracts are the best examples of the last class.

STOMACH POISONS.

ARSENATE OF LEAD.

2 pounds (powdered) to 50 gallons of water or fungicide.
⅔ ounce or 10 level teaspoonfuls to 1 gallon of water or fungicide.

Arsenate of lead as a liquid spray is probably the most extensively used of the stomach poisons and can be obtained commercially in either the paste or the powdered form. The latter is to be preferred owing to the lighter weight and greater convenience in handling. Arsenate of lead can be used safely on chrysanthemum plants at the foregoing strength. It possesses good adhesive qualities and can easily be combined with certain contact insecticides and fungicides. It will operate against almost all forms of caterpillars, cutworms, leaf-tyers, and leaf-rollers, many adult beetles, and other insects which feed on the foliage.

In preparing an arsenate of lead spray the material should first be made up in a thin paste by the addition of a small quantity of water and then diluted to the required strength. On smooth foliage or leaves with a waxy surface the liquid does not stick or spread well. This difficulty is easily overcome by adding a "sticker" such as fish-oil soap or any common laundry soap at the rate of 2 pounds to 50 gallons of liquid. For smaller quantities use from one-half to 1 ounce for each gallon of spray. Objection is frequently made to the use of arsenate of lead in the form of liquid spray because of the deposit which remains on the foliage. This should not be a prime consideration, however, because it is usually the younger plants that require the spray, and the leaves affected are left behind as the plants grow.

Arsenate of lead also finds a limited use in poisoned baits for sowbugs, cutworms, etc. Pieces of fresh-cut vegetables are dusted with the powder, or clover is dipped in a strong solution. The powdered form when combined with other ingredients such as tobacco dust, or superfine sulphur, with lime as a filler, and dusted on by means of a modern hand blower gun, serves as a combined stomach and contact poison.

CALCIUM ARSENATE.

Calcium arsenate, or arsenate of lime, can be substituted for lead arsenate for the control of leaf-eating insects on chrysanthemums. Its use, however, has not been fully demonstrated, although the writer proved in preliminary tests that as a dust it does not injure the foliage. Owing to its fineness it is admirably suited for dusting when combined with superfine sulphur.

PARIS GREEN.

5 to 6 ounces to 50 gallons of water; 1 pound of lump lime.
1 teaspoonful to 3 gallons of water; 2 to 3 ounces of lump lime.

Paris green is an arsenical compound which has been widely used by florists in the past but is now gradually falling into disuse owing to the danger of burning the tender foliage and plants. It is difficult to keep it from settling and the solution has to be constantly agitated during spraying. It is probably better as a poisoned bait for cutworms, sowbugs, slugs, millipeds, etc., when 1 part of Paris

green is mixed dry with 9 parts of sugar and sprinkled over the soil. Its use as the active ingredient of poisoned bait for the control of cutworms and grasshoppers is discussed under the heading "Poisoned Bran Mash."

When applied as a spray it insures almost complete control of the black aster beetles [19] which frequently attack chrysanthemums.

WHITE ARSENIC.

This is a very active stomach poison but its use on foliage is precluded because of the severe burning likely to follow. It is finding increasing use in poisoned baits as a substitute for Paris green because it is somewhat cheaper.

POISONED BRAN MASH.

Dry ingredients:		Liquid ingredients:	
Paris green or white arsenic	½ pound.	Sirup or molasses	1 pint.
Dry bran, alfalfa meal, or middlings	1 peck.	Water	4 to 6 quarts.

6 to 8 oranges or lemons.

As well as being an excellent remedy for grasshoppers, in general, this poisoned bait is now serving as an effective poison for the control of cutworms. The white arsenic and dry bran are first mixed thoroughly together in a vessel. In another vessel stir a pint of cheap molasses or sirup into from 4 to 6 quarts of water. Then prepare a mash by slowly adding the liquids to the poisoned bran. Allow the mash to stand for several hours for the bran to take up the arsenic. Lemons or oranges finely ground up are sometimes added to make the bait more attractive.

HELLEBORE.

Liquid:		Dry:	
Hellebore	1 ounce.	Hellebore	1 ounce.
Water	1 gallon.	Flour or air-slaked lime	5 to 10 ounces.

This material is employed only where few plants are concerned. It is a powder made from the roots of the white hellebore plant, and may be used either as a dust or in solution, being effective against very young larvæ of many leaf-feeding insects.

CONTACT INSECTICIDES.

Tobacco or nicotine solutions are very generally used for the control of many soft-bodied sucking insects, and florists find them particularly valuable against aphids, thrips, rose slugs, etc. They are recognized as standard contact sprays, and can be purchased as liquid concentrates under many proprietary names either in the volatile or in the nonvolatile form. They are easily diluted to the required strength or may be combined with many standard stomach poisons and fungicides.

VOLATILE NICOTINE.

The volatile or free nicotine as a liquid is largely used for fumigation purposes by painting it on the steam pipes or by vaporizing it

[19] *Epicauta pennsylvanica* DeG.

over lamps. It is also used for spraying, but not to such a great extent as the stable forms. Directions for its use are given on the labels of the containers in which it is purchased.

NONVOLATILE TOBACCO OR NICOTINE EXTRACTS.

1 to 1¼ teaspoonfuls to 1 gallon of water.
1 fluid ounce to 8 gallons of water.
¼ pint or 4 ounces to 25 gallons of water.
Add soap at the rate of 1 ounce per gallon of solution.

The nonvolatile extract is most extensively used, comes prepared in a highly concentrated form, and should contain not less than 40 per cent of nicotine sulphate. When tobacco solutions are used alone, soap is usually added to enhance the adhering qualities.

Preparation: First heat the water, then dissolve the desired amount of fish-oil or common laundry soap in the water after shaving it into fine particles. When the soap is thoroughly dissolved, add the necessary amount of tobacco extract and apply while hot or warm. This prevents solidifying and clogging of the apparatus, especially when a fine mist spray is desired. Apply late in the afternoon or on cloudy days to prevent unnecessary burning from sunlight. Spray with the first indication of the insects, in order to prevent occurrence of a later severe infestation.

TOBACCO DUST.

Tobacco dust, applied by means of a modern hand blower gun, is effective in destroying thrips and aphids. It may be used in the pure undiluted form or mixed with a carrier such as superfine sulphur, arsenate of lead, lime, or flour, at the rate of 5 parts of tobacco dust to 5 parts of superfine sulphur, lime, or flour. But when 1 part of arsenate of lead is added for the control of leaf-eating insects, 4 parts of tobacco dust and 5 parts of the carrier may be used.

SOAP SOLUTION.

Fish-oil or hard soap	1 pound.
Water	2 to 4 gallons.

A soap solution prepared by simply dissolving either fish-oil soap or common laundry soap in water serves as a "sticker," and also as a satisfactory remedy for aphids, immature scale insects, and red spiders. When used in the more concentrated forms it should be applied while still warm, otherwise it is likely to become stiff or gelatinous. It is advisable to syringe the plants with water the day following the application. Care should also be exercised not to allow the soap solution to collect in the soil in which the plants are growing.

KEROSENE NICOTINE OLEATE.

Stock solution:	
Solution No. 1—	
Kerosene	8 parts or 1 gallon.
Oleic acid	1 part or 1 pint.
Solution No. 2—	
Volatile nicotine	2 parts or 2 pints.
Water	8 parts or 1 gallon.

Solution No. 1 is prepared by slowly pouring the oleic acid into the kerosene, stirring constantly. In another vessel make up solution No. 2 by adding the volatile nicotine to the water. The stock solution is then prepared by stirring solution No. 1 into solution No. 2 and the mixture brought to a creamy consistency by rapidly churning it for several minutes, pouring from one vessel to the other or pumping the liquid back upon itself through a bucket pump.

For use against sowbugs, earthworms, ants, millipeds, etc., dilute the stock solution 1 pint to 10 or 12 gallons of water and spray thoroughly the ashes or sand under the pots or the soil underneath the benches as well as the walks and woodwork. Avoid getting too much of this material on growing plants.

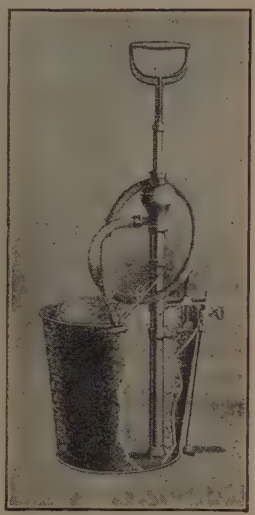

FIG. 23.—Bucket pump. (Quaintance and Siegler.)

MERCURIC CHLORID SOLUTION.

½ ounce dissolved in 3 gallons of water.

Mercuric chlorid is also known under the names bichlorid of mercury and corrosive sublimate. It acts as a contact insecticide against earthworms, slugs, snails, and the immature forms of certain soil insects, such as the larvæ of fungus gnats, when the soil in which they occur, either in the pots or beds, is drenched with a solution at the strength indicated above.

As *this chemical is a deadly poison*, the greatest care should be exercised in its preparation and handling, as well as in cleaning the vessels used. Since the bichlorid corrodes metals, it is desirable to prepare it in a glass or glazed vessel.

METHODS OF APPLYING INSECTICIDES.

SPRAYING AND DUSTING.

The prime considerations for the application of insecticides in general are promptness and thoroughness. The next is an apparatus which will break up the liquid into a fine mistlike spray and insure an even coating over the plant surfaces to which it is applied. The leading features of such an apparatus are the force pump, hose or tubing, and nozzles.

For use in the greenhouse, when only a few plants are concerned, the hand atomizer is very convenient. The bucket pump (Fig. 23) and the compressed-air sprayer (Figs. 24 and 25), however, are most suitable, the latter being preferable. Compressed-air sprayers have a capacity ranging from one-half gallon to 3 or 4 gallons, and are very practical for bench work. For large establishments outfits with a capacity of from 5 to 25 gallons, mounted on one wheel (Fig. 26) or two wheels (Fig. 27) are very desirable, as they can be wheeled throughout the houses and if necessary two leads

FIG. 24.—One of several kinds of compressed-air sprayers. (Chittenden.)

of hose may be used at one time.

It is well to observe when purchasing equipment of any type that it is so constructed as to permit easy replacement of parts likely to wear out quickly, such as the valves. The spray hose should be about three-eighths to one-half inch in diameter and of the best high-pressure type. The length will naturally vary according to conditions, although the 25 to 50 foot lengths are very desirable. A hose reducer (Fig. 28) attached to the end of a hose with a cut-off coupled to the other end of the reducer is very handy because it serves as a device or control for cutting off the spray material whenever necessary and allows the further attachment of either a spray rod or a nozzle. The spray rod so attached will be found very practical for spraying garden plants, or for plants in ground beds or on wide benches in the greenhouse, and for syringing in general.

The nozzles should be preferably of the angled type and should deliver an even, cone-shaped spray. Two types of nozzles adapted for greenhouse and gen-

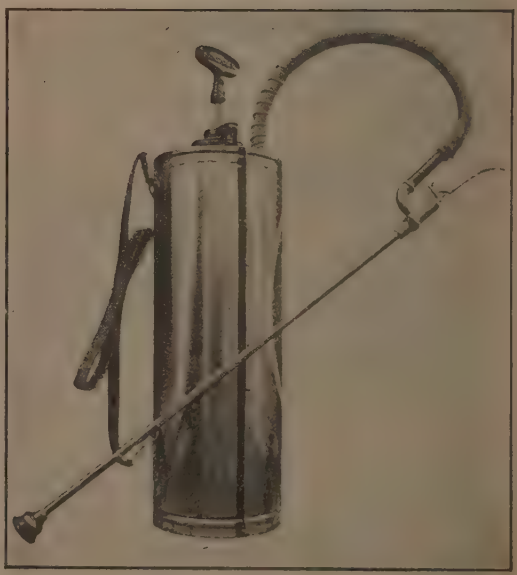

FIG. 25.—Compressed air sprayer for small spraying operations. No pumping is required while spraying. (Quaintance and Siegler.)

FIG. 26.—Barrow type of sprayer for greenhouse use.

eral spraying are illustrated in Figures 29 and 30. A straight nozzle may easily be connected to an angled type by using a 45° angle connection (Fig. 30).

Several types of the modern hand dust guns are now being used by many florists where dusting is substituted for liquid spraying (Figs. 31 and 32).

Other considerations for efficient control are the correct proportions of the ingredients in the preparation of the insecticide and

FIG. 27.—Twenty-five gallon spray tank mounted on wheels. Serviceable for greenhouse and field work.

the proper manner of application. Disregard of these factors will result in waste of material, possibly injury to the plants, and questionable results. To get the maximum results the spray material should be directed to all parts of the plant by simple wrist movements from side to side. Direct the spray up under the foliage as well as down upon the upper surfaces. An angled nozzle is very serviceable for such work. If one application is insufficient repeat at intervals of a few days. Do not wait until serious damage has been wrought before resorting to spraying. Give careful attention to the selection of the insecticide to be employed and consult text and Table 1 for specific information.

FIG. 28.—Spray rod made from brass rod, stop cock, reducer, angle connection, and double nozzle.

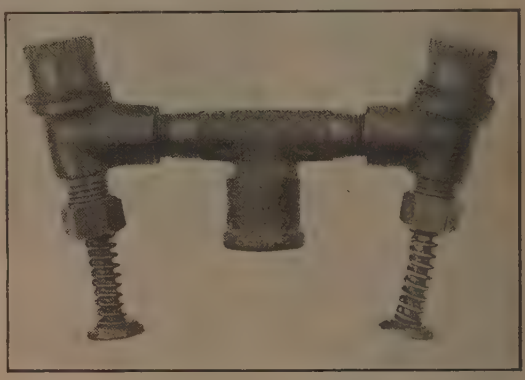

FIG. 29.—Cluster of two Vermorel (eddy-chamber type) nozzles equipped with degorger. (Quaintance and Siegler.)

FIG. 30.—Large eddy-chamber or whirlpool-disk type of nozzle and elbow or crook. (Quaintance and Siegler.)

FUMIGATION.

Fumigation, in general, is valuable for killing insects only when the plants or substances treated are in an inclosed space, the object being to fill with poisonous gases the entire atmosphere in which the insects breathe. Greenhouses are admirably suited to such an operation. Tobacco extracts in the liquid form, or commercially prepared papers impregnated with tobacco, and hydrocyanic-acid gas constitute the substances more commonly used for greenhouse fumigation.

TOBACCO FUMIGATION.

Tobacco fumigation is employed by florists for the control of aphids, thrips, and white flies, when it is not convenient to use hydrocyanic-acid gas. Tobacco stems have been used extensively in the past but have now been discarded because of the difficulty surround-

FIG. 31.—Hand duster, fan type.

ing their use. At present the burning of standard tobacco papers or especially prepared dusts impregnated with a definite amount of nicotine, or the painting of one or more steam pipes with the liquid extract, is a very convenient and efficient method of producing a

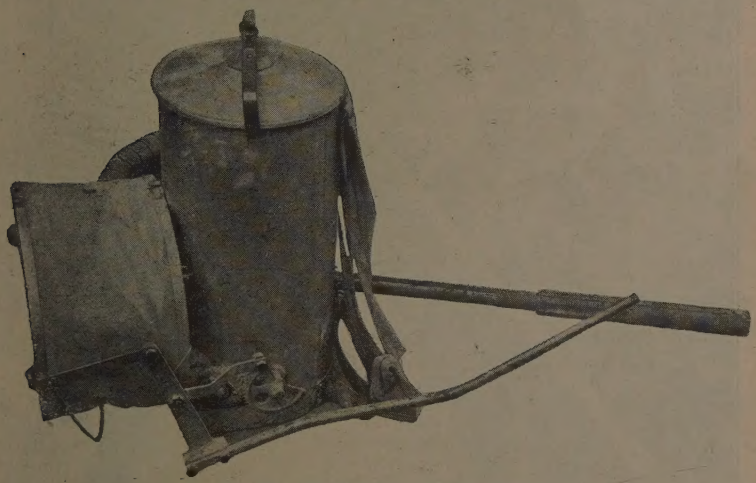

FIG. 32.—Hand duster, bellows type.

smudge. Directions are usually given on the labels of the containers in which these materials are purchased. The active ingredients of the papers or dusts deteriorate with age, hence it is better to procure papers or dusts several times during the year than to rely upon one large consignment.

HYDROCYANIC-ACID GAS.

Hydrocyanic-acid gas is by far the most efficient and cheapest method of controlling thrips, aphids, white flies, and several scale

FIG. 33.—Greenhouse prepared for hydrocyanic-acid gas fumigation. The top ventilators are arranged so they may be opened from the outside and the generators and cyanid are placed. (Sasscer and Borden.)

insects on plants grown under glass. (Fig. 33.) It has not been generally adopted because of its deadly poisonous nature, as well as its disastrous effect on the tender plants if not properly used. The

prevailing impression, moreover, is that fumigation with this gas is a cumbersome procedure and requires particular skill on the part of the operators. Fortunately, chrysanthemums are not so susceptible to the effects of this gas as more tender plants and when fumigated under proper conditions will tolerate as high as 1 ounce of sodium cyanid per 1,000 cubic feet of space, with one hour exposure, without any injury. In competent hands when used at this strength most of the pests enumerated in this bulletin can be effectively controlled by it. Although chrysanthemums can stand as much as 1 ounce per 1,000 cubic feet of space, such a strength need not necessarily be employed in each case.

Specific information on the exact hydrocyanic-acid gas dosage required for the more important insect enemies of chrysanthemums is given in Table 1.

TABULATED SUMMARY OF METHODS.

TABLE 1.—*General outline for control of insects affecting chrysanthemums.*

Insects and insecticides.	Dosage.	Number of applications.[1]	Intervals between applications (in days).
Aphids:			
Hydrocyanic-acid gas fumigation	½-ounce sodium cyanid per 1,000 cubic feet—1 hour.	2	10
Tobacco paper fumigation	1 sheet per 1,000 cubic feet [2]	3	8
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	3	8
Chrysanthemum midge:			
Hydrocyanic-acid gas fumigation	⅛ to ¼ ounce sodium cyanid per 1,000 cubic feet—1 hour.	30 to 40	Nightly.
Tobacco paper fumigation	1 sheet per 1,000 cubic feet [2]	30 to 40	Nightly.
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	10 to 15	2 to 3
Cutworms:			
Poisoned bait	See formula (p. 25).	3	3 to 4
Lead arsenate spray	⅔-ounce powder per gallon	2 to 3	10
Leaf-tyers and leaf-feeding insects:			
Hydrocyanic-acid gas fumigation for adults.	1 ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	8 to 10
Lead arsenate spray	⅔ to 1 ounce powder per gallon	2	10
Red spider:			
Water syringing	30 to 50 pounds pressure		3 to 4
Soap solution spray	1 pound soap to 4 gallons water		7
Scale insects:			
Hydrocyanic-acid gas fumigation	¾ to 1 ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	7 to 14
Soap solution spray	1 pound soap to 4 gallons water	3	7 to 10
Slugs, sowbugs, and millipeds:			
Poisoned bait	See formula (p. 25).	2	3 to 4
Thrips:			
Hydrocyanic-acid gas fumigation	½ ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	5 to 7
Tobacco paper fumigation	1 sheet per 1,000 cubic feet [2]	3	5 to 7
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	3	8
Tobacco dust	Undiluted; or equal parts tobacco dust and sulphur (or lime).	3	8
White fly:			
Hydrocyanic-acid gas fumigation	½ ounce sodium cyanid per 1,000 cubic feet—1 hour.	3	10 to 14
Miscellaneous sucking insects:			
40 per cent nicotine sulphate spray	1 part solution to 800 parts water	3	7 to 10

[1] The number of applications required in a given case will necessarily be determined by the degree of infestation and the control secured by the treatments.

[2] It is assumed that tobacco papers or dusts will be used within the period specified on the containers in which purchased; also that the user will be guided by the other directions furnished by the manufacturers.

TABLE 2.—*Equivalent weights and measures.*

Liquid measure:		
16 ounces	1	pint.
2 pints	1	quart.
4 quarts	1	gallon.
29.57 (or 30) cubic centimeters	1	ounce.
1 teaspoon	4	cubic centimeters.
2 teaspoons	1	dessert spoon.
2 dessert spoons	1	tablespoon.
Dry weights:		
28.4 grams	1	ounce.
16 ounces	1	pound.

Fumigation of greenhouses with hydrocyanic-acid gas should not be undertaken in daylight under any circumstances, nor should it be done when the temperature of the house is below 55° F., or, in most instances, above 75° F., or when the wind is high, or on hot, humid nights when the extreme differences in temperature may prove disastrous to the plants. The exposure should not exceed 1 hour, after which the house should be thoroughly aired by raising the ventilators from the outside for a period of from 10 to 30 minutes, depending on the weather. Never enter a greenhouse charged with the gas until it has been thoroughly aired. If it becomes necessary to enter the greenhouse soon after ventilation, in order to determine the temperature, the person entering should not remain longer than is necessary. *One person should not attempt to fumigate a large greenhouse alone.*

Information on the fumigation of greenhouses with hydrocyanic-acid gas may be obtained by consulting Farmers' Bulletin 880, entitled "Fumigation of Ornamental Greenhouse Plants with Hydrocyanic-Acid Gas," which may be had on application to the Division of Publications, United States Department of Agriculture.

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